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# WATER QUALITY CONTROL STUDY AND PUBLIC HEALTH ASPECTS OF THE CACHE LA POUDRE PROJECT COLORADO

Public Health Service
Denver, Colorado

June 1965

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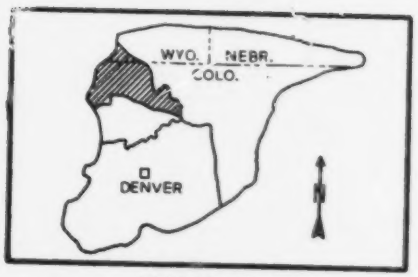
# CACHE LA POUDRE PROJECT
# COLORADO




LOCATION MAP

U. S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
PUBLIC HEALTH SERVICE, REGION VIII
DENVER, COLORADO

JUNE 1965

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Region VIII Denver (no LC number)

# WATER QUALITY CONTROL STUDY
# and
# PUBLIC HEALTH ASPECTS
# of the
# CACHE LA POUDRE PROJECT
# COLORADO


## ABSTRACT

A study was made which disclosed the need for water quality control in the study area. This need was based on the present development and the projected future population and industrial growth. The existing diversion practices and water supply make it impractical for the use of streamflow regulation as a means of water quality control in the study area at this time. Therefore, this report has made no recommendations for the inclusion of storage in Idylwilde Reservoir for the purpose of streamflow regulation for water quality control. Because of the complex nature of the water use practices and water quality problems which exist throughout much of the South Platte River Basin, a comprehensive study of the entire basin is needed to obtain optimum use of water within the basin.



Prepared at the request of and in cooperation with the Bureau of Reclamation, Region 7, U. S. Department of the Interior, Denver, Colorado

U. S. Department of Health, Education, and Welfare
Public Health Service
Division of Water Supply and Pollution Control
Region VIII

June 1965

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# INTRODUCTION

## Request and Authority

In a letter dated June 19, 1962, and a subsequent letter of May 8, 1964, the Bureau of Reclamation, Region 7, Department of the Interior requested the Public Health Service, Department of Health, Education, and Welfare, to participate in the Bureau's project planning as set forth by the Federal Water Pollution Control Act, as amended (33 U.S.C. 466 a (b)). The Bureau of Reclamation requested that the Public Health Service make a study on the need for and value of storage of water in the proposed Idylwilde Reservoir for the purpose of streamflow regulation for water quality control.

## Purpose and Scope

General objectives of the water quality control study are to assess the suitability of the water for proposed water uses and to examine the need for and value of streamflow regulation for the purpose of water quality control. The need for streamflow regulation was studied not only for the present conditions, but also for anticipated future conditions in the project area up to the year 2060. The study was limited mainly to Larimer and Weld Counties of Colorado.

Since this study has been made in advance of completion of the present study being made of the South Platte River Basin by the Public Health Service and the proposed comprehensive study of the Missouri River Basin, the findings presented are preliminary and subject to revision.

The report includes the results of a study of general public health aspects and insect vector control associated with the proposed project. The insect vector control section, prepared jointly by the Colorado State Department of Public Health and the Communicable Disease Center, Public Health Service, Greeley, Colorado presents a preliminary evaluation of the insect vector problems.

## Acknowledgements

The assistance and cooperation of many state and federal agencies are gratefully acknowledged by the Public Health Service. Particular appreciation is expressed to the following for data and advice furnished by their staff members:

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Denver, Colorado

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Denver, Colorado

Colorado Game, Fish and Parks Department
Denver, Colorado

# PART A

# WATER QUALITY CONTROL STUDY

# I. SUMMARY OF FINDINGS AND CONCLUSIONS

## Summary of Findings

1. The Bureau of Reclamation's proposed Cache la Poudre Unit is a multipurpose project that would furnish municipal and industrial water supply, recreation, irrigation, and flood control benefits. Project development would consist of constructing Idylwilde Dam and Reservoir on the Cache la Poudre River near Rustic, Colorado.
2. The major area considered in this study consists of Larimer and Weld Counties in northern Colorado and will be referred to as the study area.
3. In 1960 the total population of Larimer and Weld Counties was 125,687. The rural population comprised about 45 percent of the total. Fort Collins and Greeley, the major population centers for the area, each had an estimated population of 31,000 in 1963.
4. Irrigation is the largest user of water in the study area, with about 242,000 acres of land being irrigated in the Cache la Poudre River Basin. Municipal and industrial water supply, recreation, domestic water supply, stock watering, non-process water for the sugar beet mills, and the assimilation of municipal and industrial waste waters are the other major uses of water within the study area. The consumptive use of water within the Cache la Poudre River Basin averaged about 88 percent from 1947 to 1961.
5. Municipal wastes from Fort Collins and Greeley, the seasonal wastes from the sugar beet mills at Greeley, Eaton, and Windsor, and the

slaughterhouse at Greeley are the major sources of organic wastes in the Cache la Poudre River Basin. Many of the wastes, both municipal and industrial, do not receive adequate treatment before being discharged to watercourses. The intensive use of water for irrigation contributes to the mineralization of both surface and groundwaters in the area.

6. Water quality in the mountainous portion of the Cache la Poudre River Basin is generally good to excellent with the specific conductance seldom exceeding 200 micromhos. In the plains area there is a deterioration of water quality. Near the mouth of the Cache la Poudre River specific conductance averages about 1,800 micromhos. Waste discharges from the Greeley area have resulted in gross pollution of the river. Groundwater varies in quality from well to well, but it is generally of poor to marginal quality for domestic use. The median concentrations of hardness and dissolved solids are 727 and 1,400 mg/l, respectively.

## Conclusions

1. It is anticipated that the population of Larimer and Weld Counties will increase to about 580,000 by the year 2060. This growth is expected to be entirely urban, with the rural population declining slightly. During this period the population of Fort Collins and Greeley is expected to grow to about 240,000 and 175,000, respectively.
2. Research related industries will comprise most of the industrial growth within the study area. Expansion of food processing industries will occur in the Greeley area.

3. Municipal and industrial expansion will increase the competition for water, possibly resulting in a decline in irrigated farming in some areas. Changes in water use patterns and future development of the water resources in the mountainous areas will result in changes in streamflow patterns.

4. Water quality may continue to be a problem in the Lower Cache la Poudre River Basin. A decrease in the salinity of surface waters would occur with a decline in irrigated farming. Even with efficient secondary treatment of all municipal and industrial waste waters, there will be dissolved oxygen depletion problems in the Cache la Poudre River below Fort Collins and Greeley during periods of low streamflow.

5. Irrigated farming would be the main beneficiary of an improvement in the mineral quality or surface waters, but these benefits are considered to be minor since the amount of improvement would result in little dollar benefit from the crops grown in the area.

6. The recreational value and general aesthetic appearance of many streams, canals, and reservoirs would be improved by maintaining the concentration of dissolved oxygen at 4 milligrams per liter (mg/l) or greater. These benefits are intangible and no dollar value has been assigned to them.

7. Water quality control is needed in the Lower Cache la Poudre River Basin. The existing diversion practices and water supply make it impractical for the use of streamflow regulation as a

means of water quality control in the lower Cache la Poudre River at this time. Therefore, no recommendations have been made for the inclusion of storage in Idylwilde Reservoir for the purpose of streamflow regulation for water quality control.

8. The South Platte River Basin in particular needs a comprehensive study to determine the optimum uses of water, the quality requirements for these uses, and the best method of obtaining the desired water quality. Until this is done it is unlikely that optimum use of water will be obtained in the basin.

## II. DESCRIPTION OF THE PROJECT (1)(2)

The Bureau of Reclamation's proposed Cache la Poudre Unit is a multipurpose project that would provide municipal and industrial water supply, recreation, irrigation, and flood control benefits. Provisions for possible future installation of power facilities would be included as part of the project. The physical features of the project would consist of Idylwilde Dam and Reservoir located on the Cache la Poudre River near Rustic, Colorado. (See pullout map at the end of this report). The reservoir would have an active storage capacity of about 180,000 acre-feet and a dead storage capacity of about 11,000 acre-feet. By reducing losses to inefficient conveyance and storage systems and reducing the outflow from the basin, an average of about 20,000 acre-feet of water annually would be developed for use within the basin. Most of this 20,000 acre-feet of water would be used for municipal and industrial water supply for the growing cities of Fort Collins and Greeley.

## III. DESCRIPTION OF THE STUDY AREA

The South Platte River Basin from Denver to Fort Morgan was considered in this study with the major emphasis being concentrated on the Cache la Poudre River Basin. Draining an area of about 1,880 square miles, the Cache la Poudre River is one of the major tributaries of the South Platte River. Most of the Cache la Poudre River Basin lies within Larimer and Weld Counties of northern Colorado. About 160 square miles of the basin are in Albany and Larimie Counties of Wyoming. Construction and operation

of the Cache la Poudre Unit would affect mainly Larimer and Weld Counties with some possible changes in streamflow occuring in the South Platte River further downstream.

The study area can be divided into two general topographic sections: the mountainous area extending from the Continental Divide eastward to within 10 miles of Fort Collins and the rolling high plains country eastward from Fort Collins. Elevations range from over 13,000 feet in the mountains to about 4,400 feet near Fort Morgan. The general geology of the plains section consists primarily of alluvium and terrace deposits underlain by bedrock formations of sandstone, limestone, shale, and coal of Late Cretaceous age.(3)

In the mountainous section the climate varies from semihumid at the higher elevations to semiarid in the lower elevations. In the plains section the climate is characterized by low relative humidity, annual precipitation of about 13 inches, cold winters, and warm summers. The highest and lowest recorded temperatures at Greeley are 107°F and minus 45°F, respectively. A major portion of the precipitation falling in the plains section occurs from April through September. The growing season is approximately 140 days.(3)

# IV. WATER RESOURCES OF THE STUDY AREA

## Water Supply

Based on water supply and water uses, the Cache la Poudre Basin has been divided into two areas, the plains area (lower basin) and the mountain area (upper basin). Most of the major uses of water are found in the lower basin, while much of the water supply comes from the upper basin. The major sources of water for use in the lower basin are the following:

Mountain Supply - The mountain supply consists of runoff from the upper basin and transmountain diversions. The major portion of the runoff occurs during the months of May, June, and July resulting primarily from snowmelt in the high mountain country. The transmountain diversions have averaged 42,200 acre-feet of water annually with 39,200 acre-feet being imported above the proposed Idylwilde Dam site. The flow at this point has averaged 189,500 acre-feet annually. The total mountain supply available to the lower basin has averaged 325,100 acre-feet of water annually from 1947-1960.(1)

Colorado-Big Thompson Project - The Colorado-Big Thompson (C-BT) Project basically consists of the transmountain diversion of water from the Colorado River Basin to the Big Thompson River. Part of this water is then diverted to the lower Cache la Poudre Basin via Horsetooth Reservoir. Since 1953 the C-BT deliveries to the lower basin have averaged about 105,000 acre-feet of water per year and are expected to average about 117,500 acre-feet annually in the future.(1)

Groundwater - Groundwater development in the lower basin is rather extensive with about 1,100 wells in use in 1959.[3] It is extimated[3] that 85,800 acre-feet of groundwater was pumped in 195) primarily for irrigation. Depending on the groundwater aquifer and the size of the well, yields from irrigation wells range from less than 50 to 2,000 gallons per minute (gpm). Groundwater recharge comes from percolation of applied irrigation water, seepage from canals and storage reservoirs, and precipitation. In some areas of heavy pumping there has been a lowering of the water table and a substantial decline in yields.

Precipitation - The lower basin has a semiarid climate. The average of recorded precipitation at Fort Collins and Greeley is about 13 inches per year. Assuming equal distribution over the 242,000 irrigated acres, this amounts to an annual average of about 254,000 acre-feet of water.

There are 78 reservoirs in the Cache la Poudre Basin. The 22 reservoirs in the upper basin, ranging in size from 69 acre-feet to 10,128 acre-feet (of decreed water right capacity), have a combined decreed capacity of 50,511 acre-feet. The 56 plains (lower basin) reservoirs, ranging from less than 100 acre-feet to 17,689 acre-feet, have a total decreed capacity of 161,300 acre-feet. Most of the reservoirs are used primarily to store surplus surface flows for use during the irrigation season.

The U. S. Geological Survey (USGS) has three active gaging stations on the main stem of the Cache la Poudre River: near Rustic, at mouth of canyon near Fort Collins; and below Greeley. The period of

of record and the high, low, and average streamflow values for these stations are given below.

| Station | Period of Record | Streamflow in cfs | | |
|---|---|---|---|---|
| | | High | Low | Average |
| Near Rustic | 7 | 3,610 | 8 | 260 |
| At Mouth of Canyon | 80 | 21,000 | 1.6 | 395 |
| Below Greeley | 44 | 4,220 | 0.8 | 96 |

The flow at the station near Rustic is affected by transmountain diversions into the basin. The flows at the other two stations are greatly affected by upstream diversions throughout much of the year. Variations in diversions, combined with groundwater accretions to the river, make it extremely difficult to predict streamflows for any point in the river between the mouth of the canyon and the gaging station below Greeley. Thus, the streamflow records for the lower two stations are of little value in determining dependable streamflow in the study area.

## Water Quality

### Surface Waters

The present quality of surface waters in the Cache la Poudre River Basin ranges from excellent to conditions of gross pollution. Surface waters in the upper basin are usually of good to excellent quality, which is typical of most mountain streams in the area. The specific conductance of the water at the edge of the mountains seldom exceeds 200 micromhos, and is frequently less than 100 micromhos. The cities of Fort Collins and Greeley have water intakes at this point.

There is a sharp deterioration of water quality in the lower basin. Irrigation return flows, discharge of inadequately treated municipal and industrial waste waters, feedlot drainage, and natural sources of pollution contribute to this deterioration of quality. There is approximately a ten fold increase in the mineral content of the water as it passes through the lower basin. The specific conductance increases from an average of less than 200 micromhos to an average of about 1,800 micromhos. Figure 2 shows the monthly variations in the specific conductance of the Cache la Poudre River near Greeley and the South Platte River at Henderson and near Kersey.[1/] Near Greeley the concentration of sulfates ranges from 500 to 800 milligrams per liter (mg/l), while hardness ranges from 600 to 900 mg/l. Mineralization associated with irrigation in the basin has not been determined. The South Platte River

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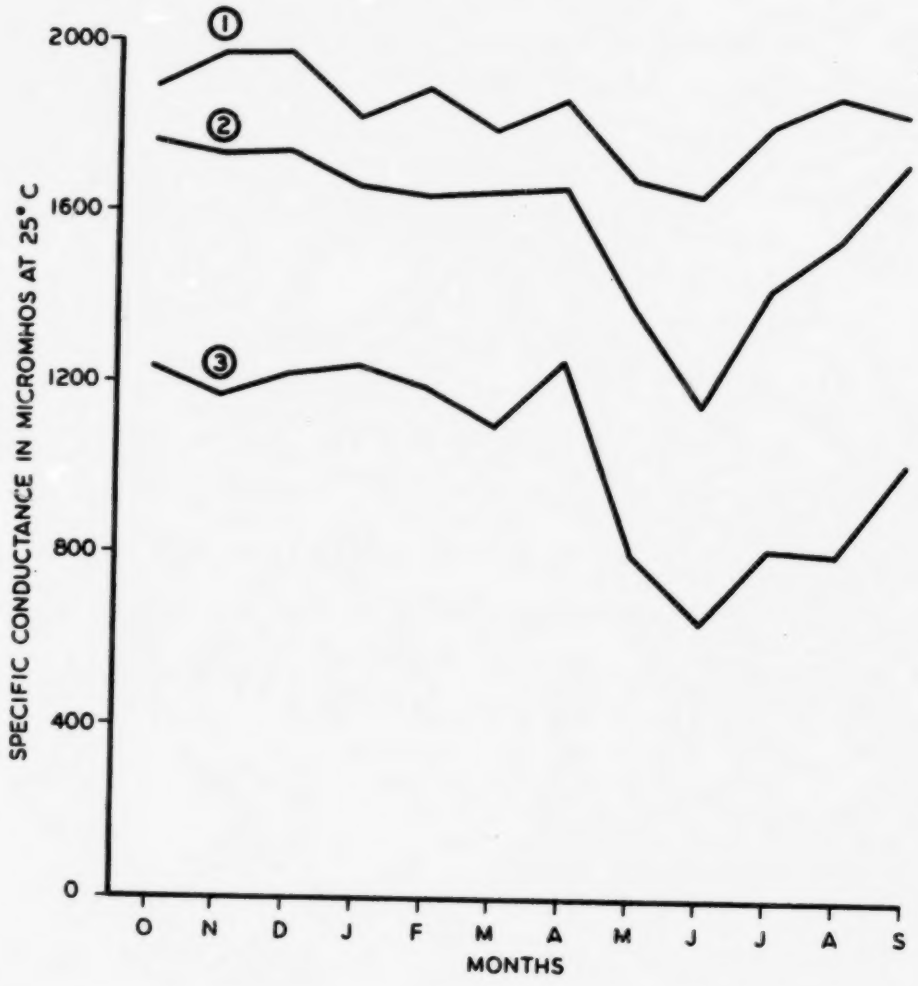
1/ Published U.S. Geological Survey data (Quality of Surface Waters of the United States) for various years from 1949 to 1963.




WATER QUALITY CONTROL STUDY
CACHE LA POUDRE RIVER BASIN

SPECIFIC CONDUCTANCE FOR THREE STATIONS

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
Public Health Service
REGION VIII DENVER, COLO.



FIGURE 2

near Kersey is of slightly better mineral quality than the Cache la Poudre River near Greeley. However, further downstream there is a deterioration of quality due to irrigation return flows and natural mineralization.

The organic and bacteriological quality of the Cache la Poudre River at the edge of the mountains is generally good. The biochemical oxygen demand (BOD)[2/] seldom exceeds 5 mg/l. At Fort Collins there is a deterioration in quality due to the discharge of inadequately treated municipal and industrial waste waters in the Fort Collins area. Below Fort Collins there are diversions from the river for direct irrigation or storage. These diversions often divert much of the waste water from the river resulting in an improvement in quality for a section of the river below the diversion. Below Greeley the river is polluted throughout the year. There are extensive sludge deposits and the river has a gray, septic appearance. The largest waste loading on the river occurs during the sugar beet campaign (October - January). During this period the river is usually polluted from Windsor to the South Platte River. Eaton Draw, which receives wastes from the sugar beet mill at Eaton, is severely polluted during this period. There are extensive sludge deposits downstream from the sugar beet mill at Windsor during the sugar beet campaign. Portions of some sludge deposits remain in the stream throughout the year. During the sugar beet campaign extensive growths of Sphaerotilus, a filamentous bacteria, are found in the streams below points of sugar beet waste discharge. Heavy growths of Sphaerotilus are a good indication of organic pollution.

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2/ Unless otherwise noted, all BOD values given in this report are for five days, 20°C.

A summary of chemical and bacteriological data for several points in the study area are given in Table 1. This data was collected during January and February 1964 and gives a good indication of the effect of sugar beet wastes on water quality. The high BOD loading in the Cache la Poudre River below Windsor and in Eaton Draw are attributed mainly to the sugar beet mills at Windsor and Eaton, respectively. Drainage from feedlots in the area may also be contributing to these high waste loadings. The relatively high BOD loadings in St. Vrain Creek and Big Thompson River were primarily the result of the waste discharges from the sugar beet mills at Loveland and Longmont and the monosodium glutumate production at Johnstown.

Groundwater

The mineral content of the groundwater in the lower basin varies over a wide range of concentrations. Table 2 gives a summary of the water quality data obtained by the U.S. Geological Survey (USGS) in a groundwater study of the lower basin.(3) As indicated by the median values of the data, the water is generally very hard and the concentrations of sulfates and dissolved solids are frequently greater than 250 and 500 mg/1, respectively.3/ Fifty-four of 107 samples had nitrate concentrations in the 20 to 45 mg/1 range. Seven samples had nitrate concentrations greater than 45 mg/1.3/ The generally poor quality of groundwater was a key factor in the formation of rural water districts in the area.

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3/ The 1962 Public Health Service Drinking Water Standards recommend that the concentration of sulfates and dissolved solids in drinking water should not exceed 250 and 500 mg/1, respectively. The concentration of nitrates should not exceed 45 mg/1 in drinking water.

TABLE 1

QUALITY OF SURFACE WATERS[1/]

| Station | Flow (cfs) | BOD | Total Suspended Solids | Ec µmhos at 25°C | pH | Total Coli. MPN per 100 ml | Fecal Coli. MPN per 100 ml |
|---|---|---|---|---|---|---|---|
| South Platte River at Highway 66 Bridge 5 miles above St.Vrain Cr. | -- | 51 | 352 | 1,230 | 7.8 | 976,000 | 346,000 |
| St. Vrain Creek near mouth | 88 | 74 | 365 | 1,390 | 7.9 | 483,000 | 43,600 |
| Big Thompson River near mouth | 72 | 145 | 74 | 1,670 | 7.6 | 47,000 | 5,900 |
| South Platte River above Cache la Poudre River | -- | 54 | 302 | 1,310 | 7.8 | 168,000 | 18,800 |
| Cache la Poudre River above Windsor | -- | 1.8 | 24 | 1,780 | 8.0 | 995 | 646 |
| Cache la Poudre River below Windsor | 24 | 482 | 390 | 1,820 | 7.7 | 2,690,000 | 9,620 |
| Eaton Draw near discharge to Cache la Poudre River (Greeley) | 10 | 1,423 | 1,690 | 1,450 | 6.4 | 72,000,000 | 1,280,000 |
| Cache la Poudre River near mouth | 78 | 349 | 210 | 1,690 | 7.6 | 6,570,000 | 327,000 |
| South Platte River below Cache la Poudre River | 417 | 89 | 217 | 1,380 | 7.8 | 1,960,000 | 95,200 |

1/ Mean values of samples collected by the South Platte River Basin Project during January and February 1964
Units: milligrams per liter except where noted.

TABLE 2

SUMMARY OF CHEMICAL ANALYSES OF WATER FROM SELECTED WELLS AND SPRINGS IN THE LOWER CACHE LA POUDRE RIVER BASIN, COLORADO [1/]

Dissolved constituents given in mg/l, except when otherwise indicated

| | Fe | Ca | Mg | Na | $HCO_3$ | $SO_4$ | Cl | F | $NO_3$ | TDS | Hardness | Ec [2/] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| High | 5.3 | 499 | 552 | 1,600 | 660 | 5,740 | 879 | 4.4 | 126 | 9,270 | 3,080 | 9,440 |
| Median | 0.03 | 192 | 58 | 160 | 359 | 626 | 24 | 0.7 | 23 | 1,400 | 727 | 1,740 |
| Low | 0.00 | 2.2 | 0.3 | 10 | 0 | 23 | 1.3 | 0.0 | 0.0 | 311 | 8 | 522 |
| No. of Samples | 103 | 109 | 107 | 112 | 112 | 110 | 111 | 108 | 107 | 111 | 111 | 111 |

1/ Chemical analyses from Colorado Water Conservation Board Basic Data Report No. 8, "Records and Logs of Selected Wells and Test Holes, and Chemical Analyses of Groundwater in the Lower Cache la Poudre River Basin, Colorado", 1961.

2/ Specific conductance in micromhos at 25°C.

## Water Uses

Recreation is the major beneficial use of water in the upper Cache la Poudre Basin. The U.S. Fish and Wildlife Service estimates(1) that total fishing on the Cache la Poudre River from the Idylwilde Reservoir site to the mouth of the canyon amounts to about 24,000 fisherman days annually. Picnicking, camping, and sight-seeing are popular along the river.

(Continued on next page)

The major beneficial uses of water in the lower basin are irrigation, municipal and industrial water supply, livestock watering, and domestic water supply. Irrigation is the largest user of water, requiring an average of 525,000 acre-feet of water annually for 242,000 irrigated acres.(1) The average available supply, including precipitation, is about 92 percent of the estimated requirement. The development of groundwater, the reuse of irrigation return flows, and the use of municipal and industrial waste waters for irrigation have resulted in a high consumptive use of water in the basin. Studies made by the Bureau of Reclamation(1) show that for the water years 1947-1960 an average of 88 percent of the net water supply in the lower basin was depleted.

Both surface and groundwaters are used for municipal and industrial purposes. A summary of public water supplies in the basin is given in Table 3. The cities of Fort Collins and Greeley have been obtaining much of their municipal water supply from the Cache la Poudre River several miles upstream from Fort Collins since about 1900. Both cities have purchased C-BT Project water to increase their available water supply. The average daily per capita use at Fort Collins is about 260 gallons and about 290 gallons at Greeley. This rate of use is expected to remain about the same or increase slightly.

Most of the smaller cities in the basin, except those served by Fort Collins or Greeley, use groundwater. Rural occupants have obtained their water from private wells. However, the generally poor quality of groundwater in the area is one of the main reasons that three rural water districts have been formed since 1960 to provide culinary and livestock water. These water districts obtain their water from Horsetooth

TABLE 3

PUBLIC WATER SUPPLIES

| Community or Facility | Population Served | Source | Treatment | Usage (mgd) |
|---|---|---|---|---|
| Ault[1] | 830E | 3 Wells | None | 0.3 |
| Eaton[1] | 1,500E | 2 Wells | None | -- |
| Evans[1] | 1,600E | See Greeley | See Greeley | -- |
| Ft. Collins[1] | 31,000E | Cache la Poudre River and C-BT Project | Coagulation, Sedimentation Filtration, Chlorination | 8.0 (260 gpcpd) |
| Greeley[1] | 31,000E | Cache la Poudre River and C-BT Project | Sedimentation, Filtration Chlorination and Fluoridation | 9.1 (292 gpcpd) |
| Kersey[1] | 380E | 2 Wells | None | 0.15E |
| Pierce[1] | 430E | 3 Wells | None | 0.03E |
| Wellington[1] | 550E | 3 Wells | Chlorination | -- |
| Windsor[1] | 1,500E | See Greeley | See Greeley | 0.16 |
| Ft. Collins-Loveland[2] Water District | 340 Connections | Horsetooth Reservoir | Micro-strainers, Sedimentation Filtration, Chlorination | 20,000 gallons/ connection/month |
| East Larimer County[2] Water District | 445 Connections | Horsetooth Reservoir | See Ft. Collins-Loveland Water District | 18,000 gallons/ connection/month |
| North Weld County[2] Water District | 350 Connections | Horsetooth Reservoir | See Ft. Collins-Loveland Water District | -- |

1/ Data from "Public Water Supplies of Colorado", 1959-60
2/ Data from combined water district office in Fort Collins, 1964

Reservoir. The combined districts serve portions of the rural area from Loveland to Fort Collins and from Fort Collins toward Greeley.

Most industries in the area obtain their water from cities and/or private wells. With the exception of the sugar beet mills, industrial water uses are generally minor. During the sugar beet campaign (October-January) the sugar beet mills use 10-15 million gallons of water per day (mgd) per mill. Most of this is surface water and is used for conveying beets and other non-process uses. Process water is obtained from municipal water supply and/or private wells.

In the plains area the fishing habitat is generally poor to non-existent due to the wide variations in streamflow caused by diversions and/or poor water quality. Before the development of irrigation in this area and the deterioration of water quality, this portion of the river supported a limited trout fishery.(14)

The area along the South Platte River from the Cache la Poudre River to Fort Morgan (52 river miles) is sparsely settled with a few small towns in the valley. Irrigated farming in this area is generally restricted to a two to three mile strip along either side of the river. Land further away from the river is used mainly for dry farming or cattle grazing. The use of surface water from the South Platte River is limited mainly to irrigation. Municipal and domestic water supplies are obtained from wells. Fishing in this portion of the South Platte River is generally poor due to the wide fluctuations in streamflow and/or generally poor water quality. Some of the off-stream reservoirs (Jackson Lake and others further downstream) support a fishery throughout the year. Due to fishing and drawdown during the irrigation season it is often necessary to restock these reservoirs.

## Present Sources of Waste Water

The major sources of municipal and industrial wastewater in the Cache la Poudre River Basin are listed in Table 4. The estimated waste loading discharged to the Cache la Poudre River and its tributaries increases from about 15,000 pounds of BOD daily during most of the year to about 162,000 pounds per day during the sugar beet campaign. Sugar beet mills produce large volumes of waste water having a large oxygen demand and high concentrations of suspended solids. Appendix A gives representative volumes and characteristics of beet sugar manufacturing wastes in the United States. Many of the sugar beet mills in the South Platte River Basin have unit waste loadings greater than given in Appendix A. However, for the purpose of this study it was assumed that the values given in the appendix are representative of waste loadings from efficiently operated sugar beet mills. These values were used in projecting future waste loadings. The three sugar beet mills located at Greeley, Windsor, and Eaton have a combined capacity of about 6,300 tons of beets daily. The mills at Greeley and Windsor use lagoons to treat their wastes, while the mill at Eaton uses only a lime pond for waste treatment. The treatment provided by these lagoons is inadequate. Samples taken in January 1964[4/] showed that the effluent from the lagoons at Windsor had an average BOD of approximately 1,100 mg/l, while total suspended solids averaged 1,120 mg/l. The BOD of the effluent from the Greeley lagoons averaged 850 mg/l, with the suspended solids averaging 93 mg/l.

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4/ Sampling program conducted by the South Platte River Basin Project during January and February 1964.

TABLE 4

MAJOR SOURCES OF MUNICIPAL AND INDUSTRIAL WASTE WATER
IN THE CACHE LA POUDRE RIVER BASIN

| City or Industry | Sewered Population | Type of Waste | Treatment | Pounds BOD to receiving stream |
|---|---|---|---|---|
| G-W Sugar Mill at Greeley | 182 employees Oct-Jan | Sugar beet processing (non-Steffens House) | Screening, lagoons, and lime pond | 26,000E 1/ |
| Greeley | 30,000 | Municipal | Trickling filter | 2,400E 1/ 2/ |
| Monfort Packing Co. at Greeley | 270 employees | Slaughterhouse | Separation of blood and paunch manure | 3/ |
| G-W Sugar Mill at Eaton | 180 employees Oct-Jan | Sugar beet processing (non-Steffens House) | Lime pond | 47,000E 4/ |
| Eaton | 1,230 | Municipal | Septic tank and sand filter | 170E 4/ |
| G-W Sugar Mill at Windsor | 180 employees Oct-Jan | Sugar beet processing (non-Steffens House) | Lime pond and lagoons | 74,000E 1/ |
| Windsor | 1,500 | Municipal | Trickling filter | 70E 1/ |
| Fort Collins | 30,000 | Municipal | Trickling filter | 1,600E 4/ |

1/ Data from samples collected by the South Platte River Basin Project in January and February 1964.

2/ Effluent from Greeley sewage treatment plant. The city is presently bypassing an unknown part of its wastes.

3/ The Monfort Packing Co. is presently discharging its wastes to the city sewers and the Cache la Poudre River. The total waste loading is estimated at 15,000 pounds BOD daily.

4/ Conference in the Matter of Pollution of the South Platte River Basin, Denver, Colorado, October 29, 1963, U. S. Department of Health, Education, and Welfare, Public Health Service.

Fort Collins, Greeley, and the slaughterhouse at Greeley are the other major sources of waste water in the Cache la Poudre River Basin. Other towns in the basin contribute to the total waste loading, but the sum of their discharges is less than 10 percent of the total waste loading. The sewage treatment plant at Greeley is presently overloaded with part of the wastes being discharged to the river without treatment. The city is planning to build a new treatment plant in 1965. The existing treatment plant will be used to treat certain industrial wastes, including wastes from the slaughterhouse. Present treatment of the slaughterhouse wastes consists of separation of blood and paunch manure and then discharging the other wastes to the Greeley sewers and to the river. With the slaughterhouse operating at full capacity, the waste loading is approximately 15,000 pounds of BOD daily. Upon completion of the new treatment plant at Greeley, the slaughterhouse will discharge all of its pollutional waste waters to the city industrial sewer after pretreatment. Runoff from feedlots undoubtedly contributes to the water quality problems in the basin. However, there is no data presently available on the volume and strength of this runoff.

Several other major sources of waste water are of interest to this study and are listed in Table 5. These sources are located in the South Platte River Basin above the Cache la Poudre River, but have an effect on water quality below the Cache la Poudre River. The effect that these waste discharges have on downstream water quality is highly variable due to diversions for irrigation or storage. During the irrigation season (April - September) waste water may flow in a stream for only a few miles before being diverted for irrigation. Much of the waste water from the

TABLE 5

MAJOR SOURCES OF MUNICIPAL AND INDUSTRIAL WASTE WATER OUTSIDE OF THE CACHE LA POUDRE RIVER BASIN [1]

| City or Industry | Sewered Population | Type of Waste | Treatment | Pounds BOD to watercourse |
|---|---|---|---|---|
| G-W MSG Plant at Johnstown | 120 employees (all year) | Monosodium Glutamate production | Lagoons | 15,000E[2] |
| G-W Sugar Mill at Johnstown | 180 employees (all Year) | Sugar beet molasses processing by Barium process | Lagoons | Included with MSG wastes |
| G-W Sugar Mill at Loveland | 300 employees Oct-Jan | Sugar beet processing (Steffens House) | Lagoons | 52,000E[3] |
| Loveland | 9,000 | Municipal | Trickling Filter | 700E[2] |
| Longmont | 12,000 | Municipal | Trickling Filter | 700E[2] |
| G-W Sugar Mill at Longmont | 300 employees Oct-Jan | Sugar beet processing (Steffens House) | Lime pond | 29,000E[2] |
| G-W Sugar Mill at Brighton | 277 employees Oct-Jan | Sugar beet processing (non-Steffens House) | Lagoons | 33,000E[2] |
| Brighton | 9,000 | Municipal | Trickling Filter | 240E[2] |
| Greater Denver metropolitan area | 945,000E | Municipal and Industrial | Varied[4] | 155,000E[2] |

1/ Major wastewater discharges located above the Cache la Poudre River that could have an effect on water quality in the South Platte River below the confluence with the Cache la Poudre River.

2/ Conference in the Matter of Pollution of the South Platte River Basin, Denver, Colorado, October 29, 1963, U.S. Department of Health, Education and Welfare, Public Health Service.

3/ Samples collected by the South Platte River Basin Project in January 1964.

4/ Treatment varies from inefficient primary treatment to efficient secondary treatment.

Denver metropolitan area is diverted for irrigation or storage within 30 miles of Denver.

During the sugar beet campaign, especially during December and January, many of the waste discharges from the Johnstown, Loveland, Longmont, and Brighton areas would normally not be diverted before reaching the South Platte River below the Cache la Poudre River. The waste loading from Loveland, Longmont, and Brighton are greatest at this time of year due to the operation of sugar beet mills. Lagoons are used to treat the wastes from the mills at Loveland and Brighton. The mill at Longmont uses a lime pond to treat a portion of its wastes, the rest being discharged untreated. Steffens waste from the Loveland and Longmont plants are condensed and shipped to the Johnstown plant for further processing. Samples of the effluent from the Loveland lagoons, collected in January 1964, had an average BOD and suspended solids concentration of 507 and 526 mg/l, respectively, with an average flow of 19 cubic feet per second (cfs). The monosodium glutamate production and the barium processing of sugar beet molasses at Johnstown are in operation throughout the year. Lagoons are used to treat part of the wastes, the rest being discharged untreated. The municipal wastes from Loveland, Longmont, and Brighton and other small towns in the area contribute to the total waste loading.

## V. THE ECONOMY

The area studied in this economic analysis extends somewhat beyond the limit of the Cache la Poudre River drainage basin to include the whole of Larimer and Weld Counties, Colorado. This choice of regional boundaries is dictated by the difficulty in obtaining standard data on anything but a county basis. In describing agricultural characteristics, the Cache la Poudre-South Platte irrigation area forms a functional region and is discussed as a unit although it includes portions of stream basins other than the Cache la Poudre. This choice of expanded study area boundaries will not materially affect the conclusions of the analysis inasmuch as the major population centers and the foci of economic activity of the two-county area are at the cities of Fort Collins and Greeley both of which are on the Cache la Poudre. It is felt that this definition of the area to be studied will best serve the objective of identifying those factors which most affect the present and future water needs and usage in the Cache la Poudre River Basin.

The study area which lies along the northern border of Colorado can be divided into three topographic segments. The eastern half of the area is flat or gently rolling plains country, the western third highly mountainous, and the central portion irrigated valleys. The economic activity is concentrated in this central portion. A highly productive relatively stable economy based on irrigated agriculture developed early in the area with the establishment of the Union Colony at Greeley in 1870 on lands of the Denver Pacific Railway. It is the

heart of the most productive agricultural area in Colorado to this day. Weld County (the eastern half of the study area) ranks first in the state in production of cattle and calves, oats, hay, dry beans, barley, and sugar beets; second in corn grain; and third in wheat.(4) The $130,266,000 worth of agricultural goods produced here in 1959 was nearly 25 percent of the state's total agricultural production. This productivity ranks Weld County ninth among all counties in the nation in terms of agricultural receipts. Larimer County is somewhat smaller and the western two thirds is very mountainous but, nevertheless, it figures importantly in the state's production of hay and cattle as well as barley, corn, dry beans and sugar beets. Although highly productive agriculturally, the area has a reasonably well diversified economy, with manufacturing employing 11 percent of the labor force, trade 18 percent, and services 26 percent compared to the 19 percent working in agriculture (see Figure 3).(5) It is the northern loop of Colorado's population belt which parallels the eastern slope of the front range of the Rockies, and it will be an increasingly important component of this developing megalopolis. Another feature of primary importance in the present and future growth of this area is its participation in Colorado's science-industry complex which has the potential of becoming Colorado's most important industry.(6)

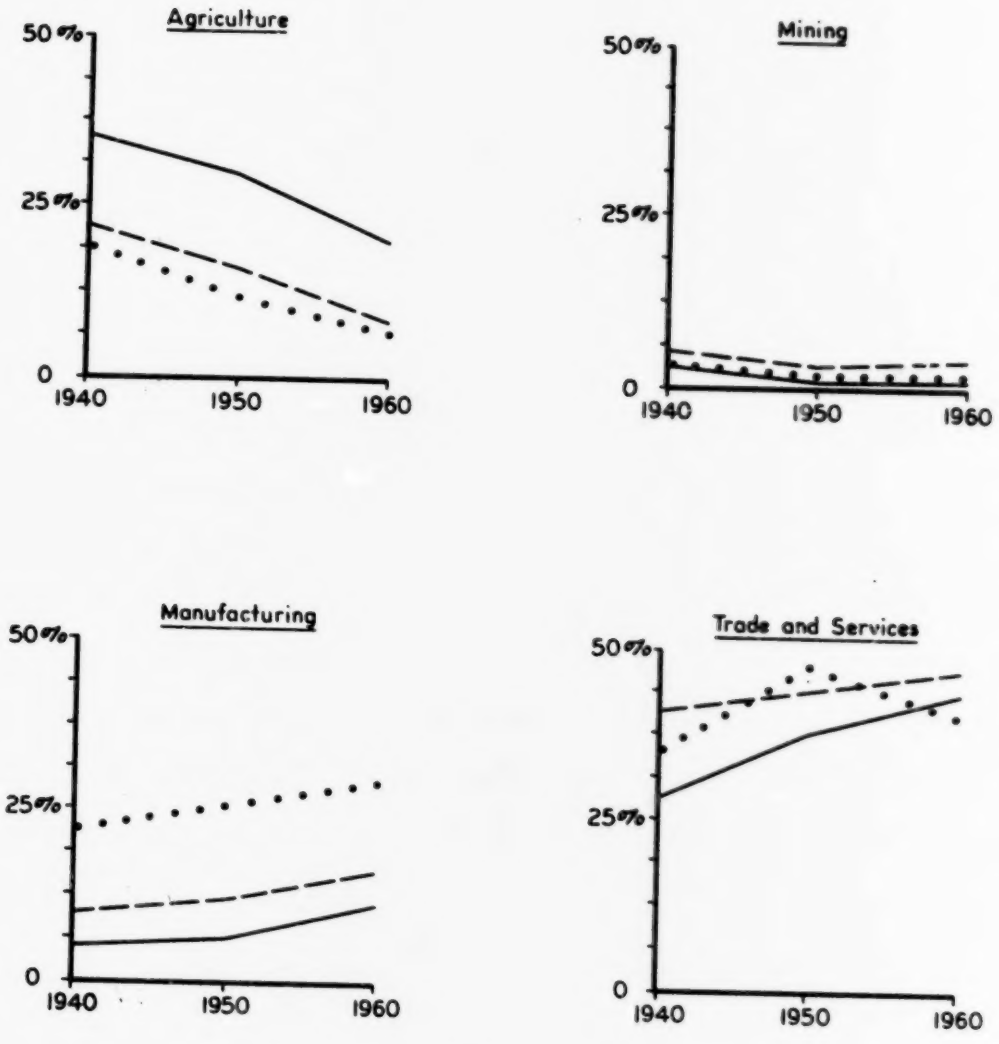
Agriculture remains the major form of economic activity, although the percentage of the labor force so employed has declined from 30 percent (11,442 people) in 1950 to 19 percent (8,617 people) in 1960. The study area has nearly 8 percent of Colorado's land in farms, but 20 percent of its irrigated land.(7) Nearly 32 percent of the land in farms of the area

Figure 3

## EMPLOYMENT BY MAJOR INDUSTRY

The Cache la Poudre River Basin compared with Colorado and the United States

(Percent of total labor force)



is irrigated. The main crops produced under irrigation are alfalfa, corn, sugar beets, dry beans, and small grains. During the decade 1949-1959 the farm population decreased by 48 percent (from 28,300 to 19,100) while the total population was increasing by 13 percent (from 111,200 to 125,600). The number of farms decreased by 18 percent (from 6,159 to 5,022) while the average size increased 27 percent to 588 acres. The most prevalent type of farm is the livestock farm (31 percent of the total) followed in importance by field crop farms and dairy farms. The number of livestock and dairy farms increased during the 1949-1959 period while the number of all other type farms decreased.

The amount of water applied per irrigated acre in 1959-1961 (2.0 acre-feet per acre) was double that applied in 1951-1953 (0.9 acre-feet per acre). This is in part due to the availability of Colorado-Big Thompson water. Coincident with this has been a trend toward greater acreages of high water using crops in the area. The harvested acreage or irrigated corn increased from 45,500 acres in 1949 to 105,500 acres in 1959; sugar beet acreage increased from 60,400 acres in 1949 to 76,200 acres in 1959 to 84,200 in 1963; alfalfa from 108,500 in 1949 to 115,500 in 1959 to 147,900 in 1963. The quantity of oats produced also increased slightly while acreages of the other major crops of the area - barley, wheat, beans and potatoes decreased.

The study area is the most important cattle producing area in the state with more than half a million cattle and calves on its farms in 1963. The total value of livestock products in 1959 was $110,378,710 which was 72 percent of the total value of farm products.

The increase in water available for irrigation seems to have two effects on economic activity. Additional water increases the marginal productivity of fertilizer which tends to increase the per acre value of the crop. Secondly, the feed grains tend to be the most responsive to irrigation, inducing growth of cattle feeding and thence, since 50 miles is about the maximum distance cattle can be transported without shrinkage, to increased meat packing and processing activities.(8) Therefore, the supplemental irrigation water made available by the Cache la Poudre Project can be expected to increase these activities in this area.

Mining is of relatively less importance in the area, providing a smaller share of employment than for the state as a whole. Nevertheless, 741,506 tons of coal, a fifth of the state's production in 1960 originated here. In 1963, 721,032 tons valued at $3,100,437 were mined.(9) This is a substantial decrease from the 1,215,363 tons produced in 1940. Employment in coal mining also dropped 50 percent between 1950-1960. There is very little commercial or domestic market for coal in the area. The major users today are the thermal power generating plants. New strip mining methods are expected to increase the production of coal though not the amount of employment in the industry.

There are approximately 150 producing oil wells in the area, mostly in Weld County. Production began in 1930 with 13,782 barrels, rose slowly to 21,375 in 1950 then spurted rapidly to a high of 2,347,818 barrels in 1957.(10) In 1963, 1,789,757 barrels with a value of nearly five million dollars were produced. There is at the present little optimism that the

declining trend in oil production of the past several years will be reversed. Gas production has paralleled oil production. The 1963 output was 3,343,819 thousand cubic feet.

Building materials constitute a major part of mining activity and include limestone used in manufacturing cement and refining sugar, dimension sandstone used for building, gypsum and mica used in wallboard and insulating materials. Cement is the most important mineral product of the area with a total value of nearly ten million dollars. Almost all of this production occurs in Larimer County and nearly three fourths is sold outside the state.

Manufacturing is currently a smaller part of the economic activity of the area (11 percent of the total labor force) than for the state as a whole (16 percent) or the United States (27 percent). However, it is the most rapidly growing segment of the economy and is increasing at a higher rate in the study area than in the state or the United States. A major part of the manufacturing in the area is based on the agricultural production. Among the more important are sugar beet refining, meat packing, and fruit and vegetable canning.(11) All of these may be expected to grow in output as the general growth of population increases demand for these food products. Meat packing has grown rapidly in the past five years. One plant at Greeley now processes 20 percent of the cattle and 30 percent of the lambs slaughtered in Colorado. Ninety-five percent of the produce of this plant is sold outside the state.(12) As the agricultural crops upon which these industries are based seem to be those most responsive to irrigation, future growth will be closely related to continued availability of water for agricultural purposes.

Sugar beet production has grown rapidly in recent years (a 30 percent increase in acreage in the past 13 years) and is refined locally in seven mills. Sugar production is closely regulated and future expansion will be a function of government policy and developments in other areas as well as local conditions.

One of the major industries in the area is higher education. This is reflected in a higher proportion of workers in educational services - 11 percent compared to less than 7 percent for the state of Colorado and 5 percent for the United States. The most important institution involved is Colorado State University which has grown in enrollment from 6,000 in 1960 to 10,000 in 1964. This growth has been accompanied (or caused) by a considerable broadening in curriculum, interests and activities of the University. Enrollment may continue to grow to as many as 25,000 students by 1990. Colorado State College at Greeley remains a specialized teachers training college and does not have the potential for overall growth that CSU has, although it has grown from 1,902 in 1950 to 4,250 in 1960. In addition to the expansion in population and service industries directly stemming from functions of CSU, is the potential growth in research related industries and government activities that seem to have an affinity to the scientific research facilities and personnel of Universities. If a science-industry complex develops in Colorado, and there is considerable evidence that one will, Fort Collins and vicinity can be expected to be a major beneficiary.(13)

Among the major resources of the study area must be included its mild dry climate and juxtaposition to scenic mountain areas. The western portion of the area is one of the nation's popular tourist areas - Estes Park and Rocky Mountain National Park. Tourism is presently important

to the economy of the study area from Fort Collins westward. Larimer County was one of two counties of the state in 1962 in which tourists spent more than ten million dollars.(15) Rocky Mountain National Park had more than one million visitors during January - July 1964, almost twice as many as the second most visited attraction in the state. These amenities of climate and topography will be important to the future economy,(13) not only for increased tourist activity, but also for the attraction exerted upon research oriented industry which tends to locate where its highly skilled and professional personnel prefer to live rather than to product or raw material markets. Instances of this may be seen in the location of an electronics firm in Loveland - now the most important single element in that city's economy - and numerous such cases in nearby Boulder. This trend can be expected to continue and accelerate despite the region's remoteness from major centers of population and markets of the nation. It is expected that much of the product of the area will be of the small bulk high value variety.

The population of the area is growing rapidly although not as fast as is the state total. Four decades ago it was the eastern most agricultural portion of the area that was growing fastest. In the past two decades the central portion along the mountain front has seen the most rapid growth. Greeley, always the larger of the two major cities in the area, and the service center of the eastern agricultural area, has, within the past year, been surpassed in size by Fort Collins. In 1950 Greeley had a population of 20,354 compared to Fort Collins' 14,937. By 1960 Fort Collins had grown to 25,027 and Greeley to 26,314. Estimates for

1963 place the population of both cities at 31,000. This trend is expected to continue. Fort Collins and Loveland are directly in the path of the most vigorous growth. Greeley is on the fringe of the fastest growing strip and, although experiencing very considerable growth, will be outpaced by Fort Collins. A further illustration of this shift in growth patterns is the fact that during 1950-60 Weld County had a net outmigration of people, while Larimer County had a net inmigration of people. Because of the high percentage of irrigated land, the agricultural population may be expected to be somewhat more stable than the agricultural population in general and will decline less than elsewhere, but will be greatly surpassed by development in other sectors of the economy as is illustrated by the following estimates of future population growth. (Refer also to Figure 4)

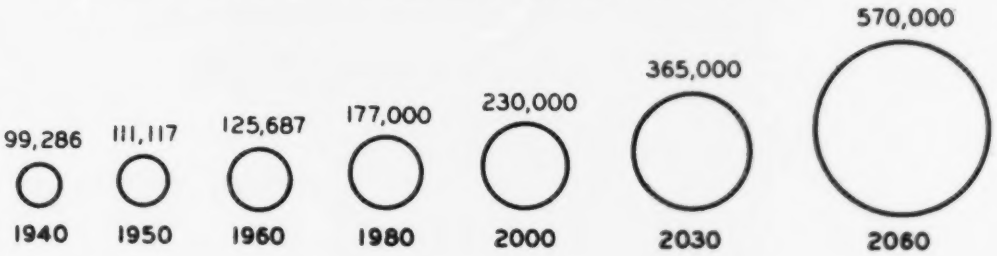
| | 1960 | 1980 | 2000 | 2030 | 2060 |
|---|---|---|---|---|---|
| Larimer County | 53,343 | 90,000 | 125,000 | 220,000 | 330,000 |
| City of Fort Collins | 25,027 | 50,000 | 80,000 | 150,000 | 240,000 |
| City of Loveland | 10,900 | 18,000 | 25,000 | 35,000 | 45,000 |
| Weld County | 72,344 | 87,000 | 120,000 | 150,000 | 250,000 |
| City of Greeley | 26,314 | 45,000 | 70,000 | 125,000 | 175,000 |
| Total Study Area | 125,687 | 177,000 | 245,000 | 370,000 | 580,000 |

Thus evidence seems to support the conclusion that the area will continue to enjoy a high rate of economic growth. Although research related industries are expected to account for most of the industrial growth, they are not expected to require large quantities of water.

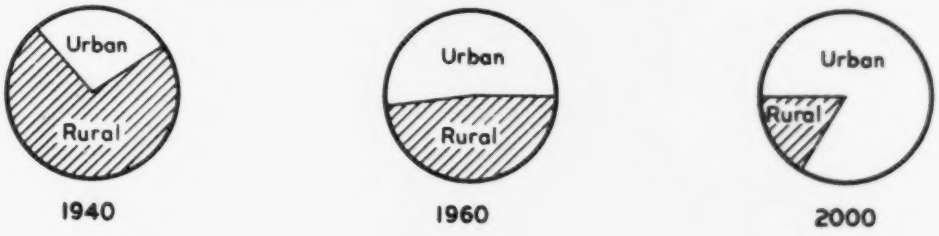
Figure 4

## POPULATION OF THE CACHE LA POUDRE RIVER BASIN

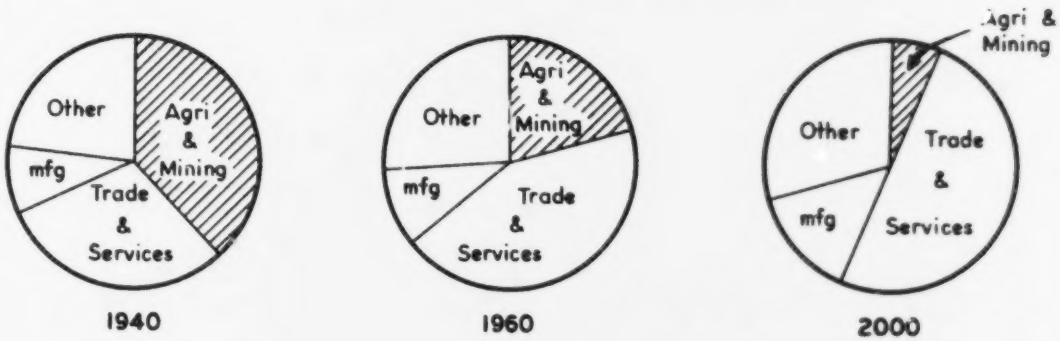
### A. Past and Projected Future Population Growth




### B. Urban and Rural Share of the Population




### C. Distribution of Labor Force among the Major Industries



## VI. FUTURE WATER USES

Recreation is expected to continue to be the major beneficial use of water in the upper Cache la Poudre River Basin. The anticipated population growth along the edge of the mountains will result in increased usage of mountain streams, lakes, and reservoirs for recreational purposes. In the lower basin irrigation and municipal and industrial water supply are expected to continue to be the major uses of water. The cities of Fort Collins and Greeley are expected to develop their present water rights to a maximum by the year 2000 or sooner.(1) To obtain additional water these cities will have to import more water into the basin and/or acquire additional water from within the basin. Much of this additional water may be water that is presently being used for irrigation. Urban development will remove some land from irrigated farming and the purchase of water rights by cities may remove additional land from irrigated farming. The increase in municipal and industrial use of water and a decline in irrigation will cause some changes in streamflow patterns. There will be increased flows downstream from Fort Collins and Greeley due to increased watewater discharges, but a decrease in irrigation return flows in some areas. One effect of these changes would be to increase irrigation at points further downstream where there are presently shortages in irrigation water. These changes are expected to occur gradually over many years.

Future water use patterns along the South Platte River downstream from the Cache la Poudre River are expected to remain essentially the same except for possible increased recreational use of water. The Bureau of Reclamation is proposing to construct a multipurpose reservoir at the Narrows (eight miles upstream from Fort Morgan) to be used primarily for flood control and supplying irrigation water to downstream areas. There is the possibility of large recreational use of this proposed reservoir.

## VII. WATER QUALITY CONTROL

### Future Sources of Waste Water

Municipal and industrial waste water discharges and irrigation return flows will continue to be the major sources of waste water in the Cache la Poudre River Basin. Feedlot drainage and storm runoff from urban areas will also contribute to water quality problems but to a lesser extent. The pollutional effect of municipal and industrial waste waters discharged to watercourses will be greatly dependent on the amount of waste treatment provided. The Federal Water Pollution Control Act (33 U.S.C. 466 et seq.) states that the inclusion of storage for regulation of streamflow for the purposes of water quality control shall not be provided as a substitute for adequate treatment or other methods of controlling waste at the source. The South Platte River Basin Project, upon completion of its investigations, will make recommendations for waste water discharge requirements. However, these recommendations will not be available until about 1967. For the purpose of this study adequate treatment was considered equivalent to efficient secondary treatment with at least 85 percent removal of BOD.

Table 6 shows the projected waste discharges for the years 1980, 2000, 2030, and 2060. The following assumptions were used in making these projections:

1. Municipal waste waters, except for Greeley, will contain 0.20 pounds of BOD per capita per day. Greeley's municipal waste water averages 0.28 pounds of BOD per capita per day.
2. The sugar beet mills will discharge before waste treatment 16 pounds of BOD per ton of beets processed.

TABLE 6

ANTICIPATED FUTURE MUNICIPAL AND INDUSTRIAL WASTE LOADINGS DISCHARGED TO WATERCOURSES AFTER TREATMENT [1]

| City or Industry | (Pounds of five day BOD per day) 1980 | 2000 | 2030 | 2060 |
|---|---|---|---|---|
| Fort Collins | 1,500 | 2,400 | 4,500 | 7,200 |
| Greeley | | | | |
| Municipal | 1,900 | 2,950 | 5,250 | 7,350 |
| Industrial [2] | 1,350 | 1,350 | 1,350 | 1,350 |
| G-W Sugar Mill at Greeley [3] | 5,300 | 5,300 | 5,300 | 5,300 |
| G-W Sugar Mill at Eaton [3] | 4,550 | 4,550 | 4,550 | 4,550 |
| G-W Sugar Mill at Windsor [3] | 5,300 | 5,300 | 5,300 | 5,300 |
| Loveland | 540 | 750 | 1,050 | 1,350 |
| G-W Sugar Mill at Loveland [3] | 8,400 | 8,400 | 8,400 | 8,400 |
| G-W Sugar Mill at Longmont [3] | 8,650 | 8,650 | 8,650 | 8,650 |
| G-W Sugar Mill at Brighton [3] | 5,300 | 5,300 | 5,300 | 5,300 |
| G-W Plants at Johnstown | 2,450 | 2,450 | 2,450 | 2,450 |

1/ Assuming 85 percent removal of BOD.

2/ Future increase in industrial waste loading included with future municipal waste loading.

3/ Assuming sugar beet campaign lasts from October 1 - February 15.

3. Sugar beet processing will remain at the present level.
4. All municipal and industrial waste waters will receive adequate treatment with at least 85 percent removal of BOD.

## Water Quality Criteria

Dissolved mineral concentrations and dissolved oxygen were the only water quality criteria used in considering the need for water quality control in this study.

In the surface waters of the study area individual mineral constituents, such as chloride and boron, are generally not present in sufficient concentrations to have an adverse effect on irrigation uses of the water. The concentration of dissolved solids in irrigation water affects the leaching requirements, and if the concentration is too high, they have toxic effects on plants. The concentration at which dissolved salts become important depends on the crop being irrigated, the type of soil, and the method of irrigation used. Since irrigated farming is quite extensive in the study area, it appears that the quality of surface water is generally satisfactory for irrigation. In the 1962 Public Health Service Drinking Water Standards it is recommended that the concentrations of sulfates and dissolved solids in drinking water should not exceed 250 and 500 mg/l, respectively. For municipal use a hardness of less than 100 mg/l as calcium carbonate is desirable. For industrial uses the quality requirements depend on the use, varying from almost pure water to brackish water.

In surface waters adequate concentrations of dissolved oxygen, along with many other criteria, are necessary to maintain the general

aesthetic appearance and to provide a healthy environment for aquatic life. The formation of odoriferous and corrosive gasses, such as hydrogen sulfide, can result from anaerobic conditions in streams, canals, and reservoirs. Hydrogen sulfide has an objectionable odor (rotten eggs), and can cause corrosion of metal structures and the discoloration of painted surfaces. A minimum dissolved oxygen concentration of 2 mg/l is necessary to avoid these nuisance conditions. For the propagation of warm water fish a minimum concentration of 4 mg/l is desirable. For maintaining the general aesthetic appearance of surface waters a minimum dissolved oxygen concentration of 4 mg/l is generally considered necessary and will be used in this study in determining streamflow requirements.

Future Water Quality

By providing proper watershed management and maintaining adequate sanitation facilities at all recreational areas, water quality in the upper Cache la Poudre River Basin should continue to be satisfactory for all projected uses. No need is foreseen at this time for any additional water quality control measures for the upper basin. In the lower basin water quality may continue to be a problem. With a decline in irrigation in the basin there may be a slight decrease in the mineralization of surface waters. However, increased irrigation further downstream would probably offset any upstream improvement in mineral quality. Even with efficient secondary treatment of all municipal and industrial wastewaters there will be dissolved oxygen depletion problems in the Cache la Poudre River below Fort Collins and Greeley. This is expected to occur most frequently below Greeley during July, August, and September when water temperatures are high (20-30$^{o}$C) and streamflows are low due to upstream diversions for irrigation.

## Water Quality Control Benefits

In considering the need for water quality control it is necessary to determine the benefits that would result from improvement in water quality. With the present and projected future water uses, irrigation would be the major beneficiary of any improvement in the mineral quality of the surface waters in the study area. By reducing the concentration of dissolved solids in the irrigation water it is possible to reduce the leaching water requirements. However, with the present irrigation practices, these benefits, in general, are considered to be minor since the percolation losses are usually greater than the leaching requirements. As water becomes more valuable more efficient methods of irrigation will be utilized. Benefits to present industrial uses of surface water would not be substantial due to the limited amount of surface water presently being used by industries. A substantial improvement in quality would increase the desirability of using surface water for industrial purposes. However, preliminary analysis indicated that water quality control to improve the mineral quality of surface waters in the Cache la Poudre River Basin does not appear to be practical at this time. (This is explained in more detail later in the report.) Therefore, no benefits have been determined for improvement in mineral quality.

Both tangible and intangible benefits would be derived from maintaining adequate concentrations of dissolved oxygen (4 mg/l or greater) in the surface waters of the study area. Fisheries could be developed in many parts of the lower Cache la Poudre River Basin and further downstream in the South Platte River. The recreational value and general aesthetic appearance of many streams, canals, and reservoirs would be

improved. Although the potential recreational value is limited, it would be beneficial to those portions of the study area that are one-two hours drive from the mountains. As the population of the area grows, this will become even more important. Due to the intangible nature of most of these benefits, no dollar value has been assigned to them.

## Water Quality Control

Theoretically three methods could be used, either separately or in combination, to reduce the salinity of surface waters in the lower Cache la Poudre River Basin: control or elimination of the causes of mineralization; removal of dissolved minerals by the use of a desalinization process; and dilution with better quality water. A reduction of salinity could be accomplished by partial or complete elimination of irrigation. However, this is not presently economically justifiable since irrigated farming comprises a large portion of the economy of the area. At this time the only foreseeable reduction in irrigated farming will result from the loss of land and/or water to urban and industrial development. With the present technological development, desalinization would be an expensive method of improving the mineral quality of surface waters within the study area. At a cost of 10 cents per 1,000 gallons, an optimistically very low value, it would cost about thirty-two dollars to treat an acre-foot of water. The cost of using desalinization as a means of controlling the mineral quality of surface waters in the study area would be prohibitive and cannot be realistically considered at this time. The only potential economical use of desalinization in the study area is the treatment of surface of groundwater for municipal or industrial uses.

In an irrigated area where the rate of water reuse for irrigation is high and the overall percent of consumptive use is high, streamflow

regulation is not an efficient means of controlling the mineral quality of water. Upstream diversions and use of the better quality diluting water would partially or completely eliminate any downstream improvement in quality. To obtain the maximum improvement in mineral quality the dilution water must remain in the stream until it reaches the place where the quality improvement is desired. Another method would be to use a separate conveyance system to get the dilution water to the area where it is needed. Because of the present and projected future high consumptive use of water, the use of streamflow regulation as a means of controlling mineral quality in the study area does not appear to be practical at this time.

The diversion of water for irrigation or storage complicates the problem of maintaining the concentration of dissolved oxygen at 4 mg/l or greater in the surface waters of the study area. The off channel storage reservoirs and many of the diversion canals have lower reoxygenation capacities than the Cache la Poudre and South Platte Rivers. Thus, while the concentration of dissolved oxygen in the river may be 4 mg/l, anaerobic conditions may be present in the reservoirs or canals. The use of waste waters for irrigation acts as tertiary waste treatment. The biological oxidation occuring in the top few inches of soil and the filtering action of the soil will reduce the BOD concentration and remove many of the pathogenic organisms present in the water. Because of the many variable conditions that could exist in the off channel reservoirs and diversion canals, all considerations of dissolved oxygen concentrations were limited to the Cache la Poudre and South Platte Rivers.

In determining the streamflow requirements needed to maintain 4 mg/l of dissolved oxygen in the Cache la Poudre River two sets of conditions were considered: (1) no diversion of water from the river between Fort Collins and the mouth and (2) complete diversion of the entire flow of the river between Fort Collins and Windsor. With a continuation of the present diversion practices the streamflow should fluctuate between these two extreme conditions. The projected waste loadings for the year 2060 and assumptions listed in Appendix B were used in determining the streamflow requirements for the Cache la Poudre River. No consideration was given in this set of determinations as to water quality in the South Platte River. It was first necessary to determine if streamflow regulation was practical for the Cache la Poudre River.

The streamflow requirements for the Cache la Poudre River for the year 2060 are given in Table 7. Even though the waste loadings are greater during the sugar beet campaign, the streamflow requirements are greatest during the summer months because of the warmer water temperatures occuring then. Increased temperature decreases the solubility of oxygen in water and increases the rate of biological activity. Thus dissolved oxygen depletion problems are more likely to occur with warmer water temperatures.

Providing streamflow regulation for water quality control in the Cache la Poudre River would be a complicated problem and may not be economically practical. Some of the more important problems to overcome are the following:

1. The amount of water needed in the river for waste assimilation will vary with the changes in diversions. These changes may occur daily or even every few hours.

TABLE 7

STREAMFLOW REQUIREMENTS FOR THE CACHE LA POUDRE RIVER [1]

| Month | Average Water Temp. °C | Number of Days | No Diversions[2] Flow[4] Above Ft. Collins | Complete Diversion[3] Flow[4] Above Windsor[5] | Complete Diversion[3] Flow[4] Above Greeley |
|---|---|---|---|---|---|
| January | 5 | 31 | 15 | 25 | |
| February[6] | 5 | 14 | 15 | 25 | |
| | 5 | 14 | 15 | -- | 15 |
| March | 5 | 31 | 15 | -- | 15 |
| April | 10 | 30 | 18 | -- | 25 |
| May | 15 | 31 | 45 | -- | 40 |
| June | 20 | 30 | 90 | -- | 70 |
| July | 25 | 31 | 180 | -- | 90 |
| August | 25 | 31 | 180 | -- | 90 |
| September | 25 | 30 | 180 | -- | 90 |
| October | 15 | 31 | 100 | 90 | |
| November | 10 | 30 | 50 | 50 | |
| December | 5 | 31 | 15 | 25 | |

1/ Based on projected waste loadings for year 2060, after 85 percent removal of BOD, and minimum allowable dissolved oxygen concentrations of 4 mg/l on the Cache la Poudre River.

2/ No diversions between Fort Collins and mouth of river.

3/ Complete diversion of entire flow between Fort Collins and Windsor.

4/ Flow in cubic feet per second.

5/ Flow needed at Windsor because of wastes from sugar beet mill at Windsor.

6/ Sugar beet campaign was assumed to run from October 1 to February 14.

2. The flow of the Cache la Poudre River in the lower basin, especially near Greeley, is often very erratic due to diversions and the seasonal variation in the availability of water. This makes it very difficult to depend on a reliable base flow in the river.

3. The effects of items number 1 and 2 combined make it very difficult, if not impossible, to determine the amount of water needed on storage for streamflow regulation.

4. The rather limited amount of water in the basin and the high consumptive use of water reduces the amount of surplus water available for streamflow regulation. Much of the surplus water available in the basin is in the form of irrigation return flows, municipal and industrial wastewater, and storm runoff. Most of this water is in the lower basin and is not readily controlled for use in streamflow regulation.

5. The state of Colorado does not recognize streamflow regulation for water quality control as a beneficial use of water. Therefore, any upstream water user with the water rights and the priority can divert the water from the river. During a dry year there is a very good possibility that the dilution water would be diverted before it reached the area where it was needed. Changes in the laws will be needed before streamflow regulation can be used in many areas of the state.

Until these many problems can be overcome, streamflow regulation does not appear to be a practical means of water quality control in the Cache la

Poudre River Basin. Therefore, at this time no recommendations can be made for the inclusion of storage in Idylwilde Reservoir for the purpose of streamflow regulation for water quality control.

## VIII. ADDITIONAL STUDIES NEEDED

Not only in the study area, but throughout much of the South Platte River Basin the problem of water quality control is complicated by the intensive use and reuse of water and the highly variable streamflows caused by diversions for direct irrigation or storage. Water uses in any given part of the basin are often affected by water uses and and water rights in other parts of the basin. Future water resources development may have significant effects on water uses and water quality in downstream portions of the basin. Because of the complex nature of these problems a comprehensive study of the entire South Platte River Basin is needed to determine optimum water uses, the water quality requirements for these uses, and the most economical methods of obtaining the necessary quality requirements. Until this is done, it is unlikely that optimum use of the water resources of the South Platte River Basin will be obtained.

PART B

PUBLIC HEALTH ASPECTS

# I. SUMMARY AND RECOMMENDATIONS

## Summary

1. Project development will improve the economy and permit the establishment of a more healthful environment.

2. Recreational development contiguous to reservoirs will be partially regulated by the topographical features of the shoreline.

3. Temporary construction camps may be necessary to serve the contractor's employees.

4. As overall watershed management involves many interests, it is essential that the effect on public health be fully coordinated with state and/or local health departments.

5. Mosquitoes are the principal vectors which might be affected by the proposed project, although other insects and rodents may be involved.

6. Colorado tick fever is endemic in the area of the proposed Idylwilde Reservoir.

7. Provision for the prevention and control of man-made vector sources will increase the overall benefits of the project.

## Recommendations

Overall watershed management requires the cooperation of many interests to assure that development and activities will minimize the potential public health hazards associated with the proposed project. It is recommended that the following be given due consideration in development of the Cache la Poudre Project:

1. That the water users' organization (i.e., Water Conservancy District) operating as the general administrative and contracting agency for the project should:

    a. Alert all water users of the potential public health hazards associated with using inadequately treated water for culinary purposes;

    b. Exert all possible precaution to exclude inadequately treated sewage and barnyard drainage from project canals, laterals, and drains;

    c. Wherever and whenever possible assist the project inhabitants and communities in development of approved water and sewerage facilities; and

d. Operate and maintain project facilities in accordance with established criteria.

2. That potential recreational areas be investigated and at least minimum water and sanitary facilities be provided in accordance with Colorado State Department of Public Health regulations.

3. That a sanitary survey of proposed construction campsites be made and all camps be provided with water and sanitary facilities in accordance with Colorado State Department of Public Health regulations.

4. That recreational activities, at reservoirs utilized as a source of public water supplies, meet the requirements established by the Colorado State Department of Public Health

5. That person or persons responsible for a public water supply establish suitable controls over the use of watershed areas tributary to the supply to insure production of raw water meeting the quality requirements established by the Colorado State Department of Public Health.

6. In order to minimize public health hazards, every possible effort should be made to avoid creating conditions which will increase populations of mosquitoes and other arthropods and rodents of public health importance or result in increased exposure of humans to vectors of both aquatic and terrestrial origin. It is recommended that:

   a. Where applicable, the principles and practices for prevention and control of vector problems associated with reservoirs outlined in Appendix C be followed.

## II. PUBLIC HEALTH AND RELATED PROBLEMS

### Public Health Services

Project development will improve the economy of the area so that local residents benefiting either directly or indirectly will be in a position to enjoy a higher standard of living. Among other necessities, this involves the establishment of a healthful environment. Some of the more important factors in creating such an environment include the development of safe and ample culinary water supplies, proper waste disposal facilities, and insect and rodent control measures.

### Recreational Development

Concomitant with the development of water resources comes the increased use of lands adjoining reservoirs for recreational purposes. This presents major problems of sanitation involving those of coordination of the multiple use policy and prevention of water pollution. The extent of recreational development, planned or spontaneous, immediately contiguous to reservoirs will be partially regulated by the topographical features of the shoreline. Also, a receding shoreline during the irrigation season, together with an accumulation of mud deposits above the water level, will create hazardous and undesirable conditions for some water-based recreational activities.

### Construction Phase of Project

Limited housing accommodations are available in the vicinity of the construction site near Rustic to serve the contractor's employees during the construction phase of the project. Under these conditions a temporary construction camp may be necessary. Prior to selection of a campsite a sanitary survey of the proposed area should be made by the State Department of Public Health or the Public Health Service to assist in solving of problems which may be encountered in connection with the installation of water and sanitary facilities.

Water supplies and sanitary facilities required in connection with temporary construction camps and with permanent housing for reservoir attendants should comply with the requirements of the Colorado State Department of Public Health so as to eliminate potential health hazards.

### Sanitary Aspects of Watershed Management

As overall watershed management involves many interests, it is considered essential that proposed developments and activities on watersheds pertaining to public health aspects be fully coordinated with state and/or local health departments. These matters should be mutually considered prior to the actual development of the watershed and issuance of permits.

Adequate and safe water and sanitary waste disposal facilities, in accordance with state and/or local health agency standards, should be provided in public use areas to serve camping, picnicking, and other recreational uses. Water and sanitary facilities for private dwelling sites should also meet the established health standards. The effectiveness of the sanitation program should be evaluated periodically by a detailed sanitary survey in conjunction with laboratory analyses of water samples collected from surface and/or groundwater in the watershed.

On reservoirs constructed primarily to serve as a source for a municipal water supply, extreme caution should be exercised in considering recreational use of the reservoir. This also involves the possibility of additional pollution entering the water supply and the matter of aesthetics.

## Preliminary Vector Evaluation

### Anticipated Effects of the Proposed Project on Vector Problems

Under existing conditions, flooding of bottomlands immediately adjacent to the Cache la Poudre River during the spring runoff season creates favorable habitats for production of the voracious Aedes mosquitoes. It is anticipated that flood control storage in the proposed Idylwilde Reservoir would reduce such flooding and thereby benefit mosquito control. Since the proposed Idylwilde Reservoir would be situated in a narrow canyon with steep shorelines, mosquito production associated with the reservoir would be minimal. It appears unlikely that any special work specifically for mosquito control would be necessary in the reservoir, except possibly some minor shoreline conditioning in the extreme upper reaches.

Colorado tick fever is endemic in the area of the proposed Idylwilde Reservoir and Dermacentor andersoni, the vector of Colorado tick fever, is a prevalent tick in the area. It would, therefore, be highly desirable to incorporate tick-control measures into the development and maintenance of public use and recreational areas associated with the proposed reservoir.

### Responsibility for Vector Control

Responsibility for vector prevention and control is normally associated with land ownership or operating rights. Therefore, the agency, group, or individuals responsible for various aspects of the proposed project should be prepared to accept full responsibility for the prevention and control of vector problems resulting from the design, construction, operation, or maintenance of the project.

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APPENDIX A

REPRESENTATIVE VOLUMES AND CHARACTERISTICS OF BEET SUGAR MANUFACTURING WASTES [1/]

| Waste | Flow per ton of beets (gal.) | BOD Five day 20°C (ppm) | Suspended Solids (ppm) | Five day BOD per ton of beets sliced (lbs.) |
|---|---|---|---|---|
| Flume Water | 2,600 | 210 | 800- 4,300 | 4.5 |
| Pulp Screen Water | | | | |
| Cell Type Diffuser | 240 | 980 | 530 | 2.0 |
| Continuous Diffuser | 400 | 910 | 1,020 | 3.0 |
| Pulp Press Water | 180 | 1,710 | 420 | 2.6 |
| Pulp Silo Drainage | 210 | 7,000 | 270 | 12.3 |
| Lime Cake Slurry | 90 | 8,600 | 120,000 | 6.5 |
| Lime Cake Lagoon Effluent | 75 | 1,420 | 450 | 0.89 |
| Barometric Condenser Water | 2,000 | 40 | | 0.67 |
| Steffen | 2,640 [2/] | 10,500 | 100- 700 | 231 [2/] |

1/ Force, Stephen L., "Beet Sugar Factory Wastes and Their Treatment Primarily the Findlay System", Proceedings of the Seventeenth Industrial Waste Conference, Purdue University, May 1, 2, and 3, 1962.

2/ Per ton of 50 percent molasses processed.

## APPENDIX B

Assumptions used in making calculations for streamflow requirements for water quality control.

1. Dissolved oxygen was the only water quality parameter used in determining streamflow requirements. An absolute minimum concentration of 2 mg/l is desirable for the avoidance of nuisance conditions. A minimum concentration of 4 mg/l is desirable for the propagation of warm water fish. A minimum concentration of 4 mg/l was used in the calculations.
2. No consideration was given to water quality in diversion canals and off-channel storage reservoirs.
3. Organic waste loadings, after 85 percent removal of BOD, as listed in the section on future waste loadings, was used in making calculations.
4. The concentration of dissolved oxygen in unpolluted surface waters and irrigation return flows was assumed to be at 85 percent of saturation. After treatment, waste waters were assumed to have a dissolved oxygen concentration of 2 mg/l.
5. Values of 0.1 for rate of oxygen demand ($k_1$) and 0.3 for rate of reoxygenation ($k_2$) at $20^{\circ}$ C will be used in making oxygen-sag calculations for surface streams. Corrections will be made for different temperatures. The effect of ice cover was not considered.
6. Water temperatures as listed in Table 7 were used in all calculations. These values are considered to represent mean surface water temperatures for their respective seasons.

7. Groundwater accretions to the Cache la Poudre River and the South Platte River was assumed to remain fairly constant at about 2 cfs per river mile.

8. Average stream velocities of 1.0, 1.5, and 2.0 feet per second were used in determining time of travel between points. The velocity used depended on the streamflow being used. The greater the flow the greater the velocity.

9. All wastes from the Denver metropolitan area will be diverted before reaching the confluence of the South Platte River and the Cache la Poudre River.

10. During the irrigation season all waste waters originating in the South Platte River Basin upstream from the Cache la Poudre River will be diverted for irrigation.

APPENDIX C

## Principles and Practices for Prevention and Control of Vector Problems Associated with Reservoirs

### I. Prevention and Source Reduction Measures

#### A. For Mosquitoes and Other Aquatic Insects

1. All borrow pits and other potential ponding areas associated with construction of the dam, relocation of highways or roads, etc., which are located above maximum pool level should be made self-draining.

2. Prior to impoundage, the reservoir basins should be prepared as follows:

   a. The normal summer fluctuation zone of the permanent pool should be completely cleared except for isolated trees and sparse vegetation along abrupt shorelines which will be exposed to wave action.

   b. Dense stands of timber rooted below the normal summer minimum pool level but extending above that elevation should be cleared. In some situations, such timber may be felled and securely tied down in lieu of disposal.

   c. Borrow pits, depressions, marshes, and sloughs which will be flooded by the reservoir at maximum pool level and which would retain water at lower pool levels should be provided with drains to insure complete drainage or fluctuation of water within them.

   d. If the summer fluctuation zone of the permanent pool is limited to a few feet, consideration should be given to "building out" mosquito-producing areas located within flight range of population groups or recreational areas through the use of measures such as deepening and/or filling. This would minimize the need for repetitive measures for controlling vegetation and mosquito production.

3. After impoundage, the following maintenance measures should be carried out in all potential mosquito-producing areas located within flight range of human population groups or recreational areas frequented by significant numbers of persons:

   a. All dense vegetation should be removed periodically from flat, protected areas within the normal summer fluctuation zone of the permanent pool.

b. Vegetation, debris, and flotage should be removed periodically from all drains to insure free flows.

4. Water level management to minimize conditions favorable for mosquito production should be used to the maximum degree permitted by the primary purposes of the reservoir. This will minimize the need for repetitive measures for controlling vegetation and mosquito production.

5. As a general principle, waterside recreational areas, particularly those which have facilities for overnight human occupancy, should be located along sections of the reservoir which have a low production potential for mosquitoes and other aquatic insects of public health importance.

B. For Terrestrial Arthropods and Rodents at Recreational Areas

1. Proper storage, collection, and disposal of refuse should be practiced in order to prevent and control flies, wasps, other noxious insects, rats, wild rodents, and other small mammals.

2. All buildings should be rodentproofed at recreational areas where rodents are prevalent which may create public health hazards.

3. Debris, rubbish, and other materials which may serve as harborage for rodents and other small mammals should be removed periodically.

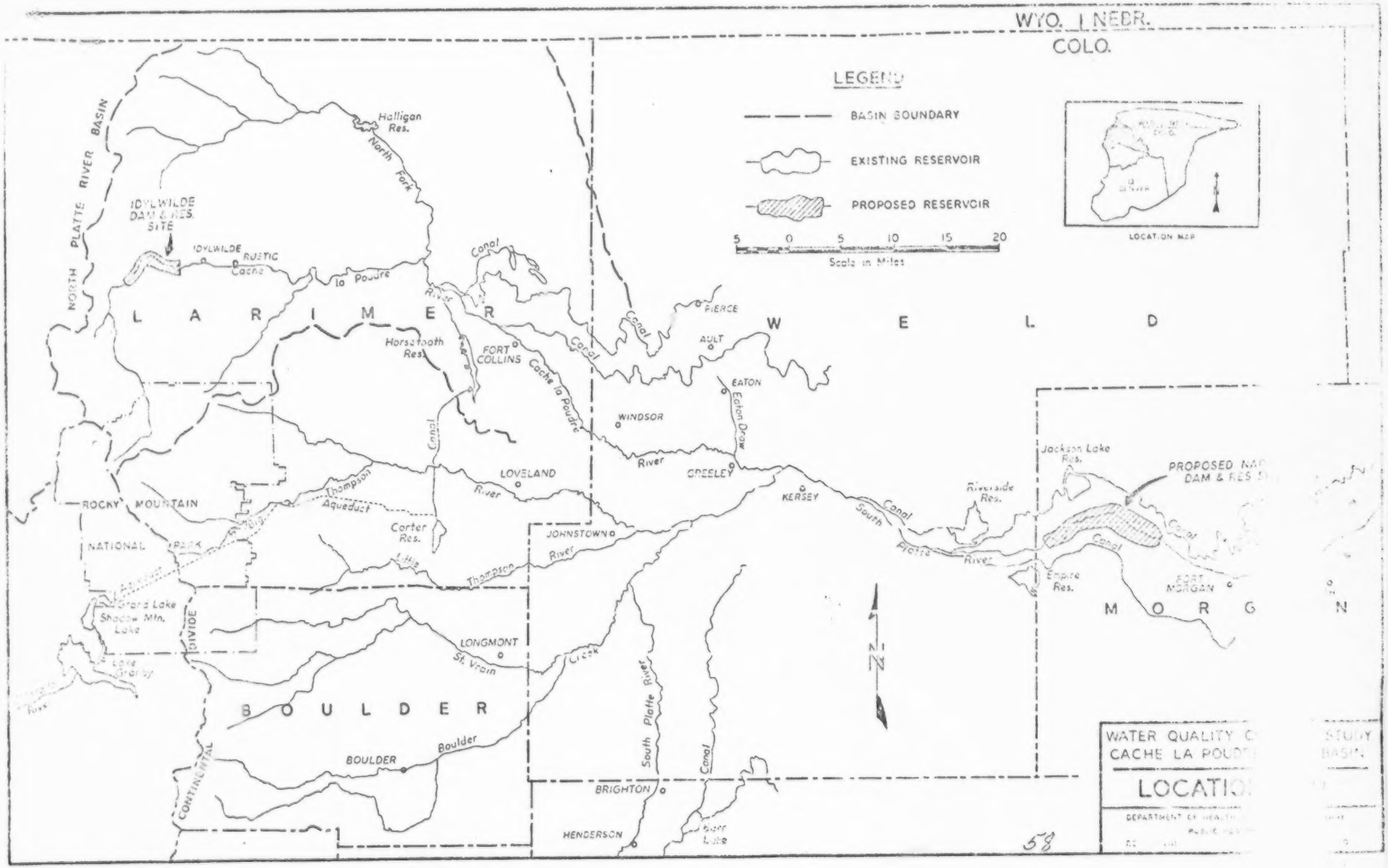
4. Brush and weeds along paths, trails, roadways, and other areas of frequent use by visitors should be removed in order to reduce the likelihood of tick infestation.

## II. Supplemental Chemical Control Measures

In situations where adequate vector control is not obtained through prevention and source reduction measures, provision should be made for supplemental use of insecticides and rodenticides to achieve the desired level of control.

## III. Vector Appraisal

Arrangements should be made for carrying out a routine program of vector appraisal as a part of normal operations of the reservoir and associated recreational areas. Inspections for adult and larval mosquitoes and other vectors are essential for planning and evaluating control measures and for adjusting control programs to meet temporary or emergency situations.


WYO. | NEBR.
COLO.
LEGEND
BASIN BOUNDARY
EXISTING RESERVOIR
PROPOSED RESERVOIR
5 0 5 10 15 20
Scale in Miles
LOCATION MAP
NORTH PLATTE RIVER BASIN
Halligan Res.
North Fork
IDYLWILDE DAM & RES. SITE
IDYLWILDE
RUSTIC
Cache la Poudre
Canal
River
L A R I M E R
Horsetooth Res.
FORT COLLINS
Cache la Poudre
Canal
PIERCE
AULT
W E L D
EATON
Eaton Drain
WINDSOR
River
GREELEY
Canal
LOVELAND
River
Thompson Aqueduct
ROCKY MOUNTAIN
NATIONAL PARK
Carter Res.
Lake
Thompson
River
JOHNSTOWN
KERSEY
South Platte River
Canal
Riverside Res.
Jackson Lake Res.
PROPOSED NAME DAM & RES. SITE
Canal
Empire Res.
FORT MORGAN
M O R G A N
Grand Lake
Shadow Mtn. Lake
Lake Granby
DIVIDE
LONGMONT
St. Vrain
Creek
South Platte River
Canal
B O U L D E R
CONTINENTAL
BOULDER
Boulder
BRIGHTON
HENDERSON
Barr Lake
WATER QUALITY C
CACHE LA POUDR
STUDY
BASIN
LOCATIO
DEPARTMENT OF HEALTH
PUBLIC HEA

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